Day-of-Week Patterns of Particulate Matter at Selected Sites in California

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Introduction

The purpose of this study is to analyze the concentrations of particulate matter (PM) by day of week using both continuous and non-continuous PM data and to describe or characterize any weekday/weekend effect on PM. Using the hourly PM data from continuous particulate monitoring method would provide additional insight into the nature of PM problem and reduce the uncertainties associated with less sampling frequencies presented previously (Motallebi and Tran, 1999).

PM Data

The particulate data used in this study were available from routine particulate matter monitoring program and the California Acid Deposition Monitoring Program (CADMP). For the routine monitoring program, particulate matter-10 micron samples (PM10) are collected over a 24-hour period using a high volume sampler equipped with a size selective inlet (SSI). Samples are usually collected from midnight to midnight every sixth day. SSI-PM10 data were analyzed for three regions from 1989 through 1998. These include San Francisco Bay Area (11 sites), Sacramento Valley (14 sites), and San Joaquin Valley (14 sites).

Continuous particulate monitoring methods have evolved in recent years. The hourly data from these methods provide additional insight into the nature of the particulate problem and remove uncertainties associated with less than daily sampling frequencies. However, the current designs of these instruments do not permit analysis for ionic and elemental constituents. The more commonly used continuous PM monitor in California is the tapered element oscillating micro-balance (TEOM). A potential limitation of this monitor is that it is heated to 30 - 50 degrees Celsius to eliminate humidity effects under a broad range of ambient operating conditions. At locations where and times when volatile secondary particulates such as nitrates and some organics are a significant portion of the total particulate mass, the PM measurements are obviously lower with the TEOM than with the traditional high-volume sampler with SSI.

At the Sacramento and Azusa sites, data on light scattering (gathered with a nephelometer) and on light absorption (the coefficient of haze -- COH) are also available. COH units are defined as the quantity of particulate matter that produces an optical density of 0.01 on the paper tape. A photometer detects the change in the quantity of light transmitted through the spot as the particulate matter collects on the paper filter tape and produces an electrical signal proportional to the optical density. A COH of less than 1.0 represents relatively clean air while a COH of greater than 2.0 represents air with a relatively high concentration of combustion-generated particles.

Methodology

The general approach was similar to the one that was applied to the SoCAB PM analysis. We first analyzed day-of-week patterns of PM10 by calculating the geometric means of SSI-PM10 and

TEOM-PM10 for each day of the week for each site. We performed statistical tests to the SSI-PM10 data to provide an indication of the magnitude of the systematic differences between days of the week relative to random day-to-day variation. For further details on the methodology, please see Motallebi and Tran (1999).

Discussion of Results

The following graphs present the results of the PM weekday/weekend effect data analyses. From these graphs several preliminary conclusions can be determined.

- Coefficient of haze (COH) and light scatter (B_{scat}) provide a relative indication of the contributions of light scattering and light absorption. The COH is a direct measure of the light-absorbing ability of the particles. Light absorption is primarily due to elemental carbon from combustion. The B_{scat} roughly measures all scattering by fine particles. The characteristics of light scattering are extremely sensitive to the size of the scattering particles. Light scattering by the large particles (>10 µm diameter) is generally not significant. As particle sizes approach the range of light wavelengths (0.1-1 µm) they become more efficient in light scattering.

- Analyses of PM10 mass from the CADMP and TEOM samplers show that Sunday is the lowest day of the week at three sites in SoCAB, often significantly different from mid-week.

- TEOM-PM10 data do not track the same pattern as the CADMP-PM10 data at all 3 sites in SoCAB. Weekday TEOM-PM10 changes are less pronounced than those using the CADMP-PM10 data.

- Across periods, day-of-week patterns of TEOM-PM10 are relatively similar for each season and period.

- Day-of-week patterns of the TEOM-PM10 data do not track the same pattern as B_{scat} data at all sites. The day-of-week patterns for B_{scat} show no change or a small change. Results of a visibility modeling study (Wexler et la., 1992) indicate that light-scattering particles dominate the visibility problem, and light absorption (mainly by black carbon particles) makes an increasingly important contribution to the extinction coefficient in the fall and winter months. Also, the results of this study show that collocated nephelometers are often in disagreement, and that no visibility model can be expected to produce exact agreement with all measured light scattering values because the light scattering data are in conflict. Please note that during the 1987 SCAQS, the light scattering values were measured by several investigators using heated or non-heated nephelometers or even slightly different instrumentation for measuring light scattering.

- At the Sacramento site, the day-of-week pattern of the TEOM-PM10 data are associated closely with the COH data. Recall that the COH is a direct measure of the light absorbing ability of the particles. Light absorption is primarily due to elemental carbon from combustion. Since elemental carbon accounts for about 10-15% of total fine particle mass in the Los Angeles Air Basin, reduced emissions of this primary PM component can potentially contribute to reduced ambient PM concentrations and associated reduced light extinction. Traffic count data in the SoCAB show a decrease in heavy-duty vehicle travel on weekends. Since heavy-duty trucks typically represent a major source of black carbon, the decrease in heavy-duty truck travel may also result in a decrease in ambient elemental carbon concentration, and perhaps a decrease in PM light extinction as well. High concentrations of PM, elemental carbon in particular, may reduce the amount of photons available to fuel ozone photochemistry near the surface.

- The results of the SSI-PM10 data at San Francisco Bay Area, San Joaquin Valley, and Sacramento Valley show no "weekend effect" for PM10. Though Sunday shows the lowest PM10, followed by Wednesday, then Saturday, at many sites, the differences are not significant at 95% level. Since there was no significant PM10 effect, we did not need to investigate PM at individual species level.

Conclusion

Given the wide variety of sources contributing to PM (e.g., primary particles and secondary particles from combustion sources) interpretation of these results in terms of weekday/weekend emissions differences is complex and should be done with caution. Performing a comprehensive air quality data analysis and three-dimensional modeling study that would test the impact of emissions changes associated with changes in emission levels, timing, spatial distributions, etc, would lead to an accurate characterization of the weekday/weekend behavior of PM.

References

Motallebi, N. and Tran, H. "Day-of-week Patterns of Particulate Matter and its Species at Selected Sites in SoCAB". 1999. It can be found on the web at: *http://www.arb.ca.gov/aqd/weekendeffect/wk_pmmass_species.pdf*.

Wexler, A.S., Eldering A., Pandis, S.N., Cass, G.R., Seinfeld, J.H., Moon, K.C., and Hering, S. "Modeling Aerosol Processes and Visibility Based on the SCAQS Data". Final Report, Contract No. A932-054, California Air Resources Board, Sacramento, CA.

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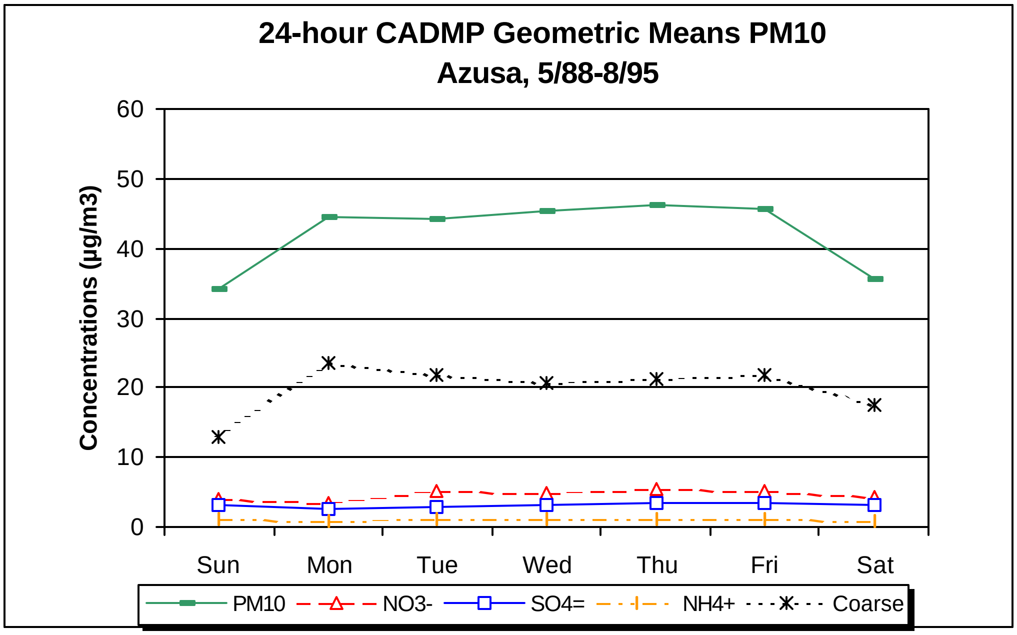
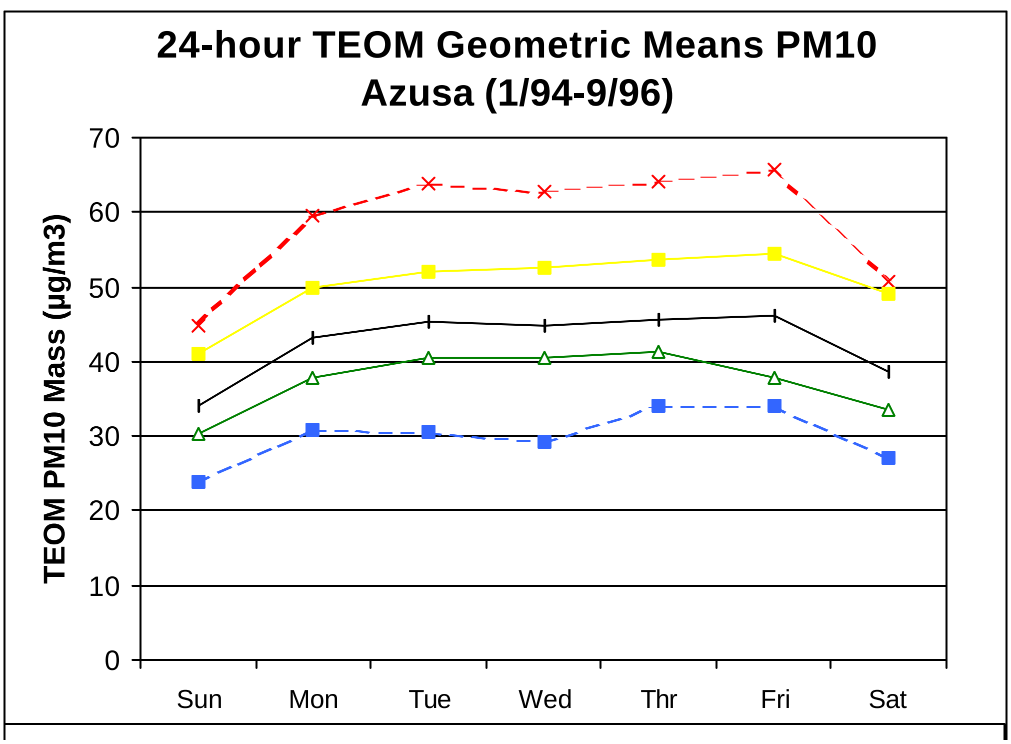


24-hour CADMP Geometric Means PM10
Azusa, 5/88-8/95
Concentrations (µg/m3)
60
50
40
30
20
10
0
Sun
Mon
Tue
Wed
Thu
Fri
Sat
PM10
NO3-
SO4=
NH4+
Coarse



24-hour TEOM Geometric Means PM10
Azusa (1/94-9/96)
TEOM PM10 Mass (µg/m3)
70
60
50
40
30
20
10
0
Sun
Mon
Tue
Wed
Thr
Fri
Sat

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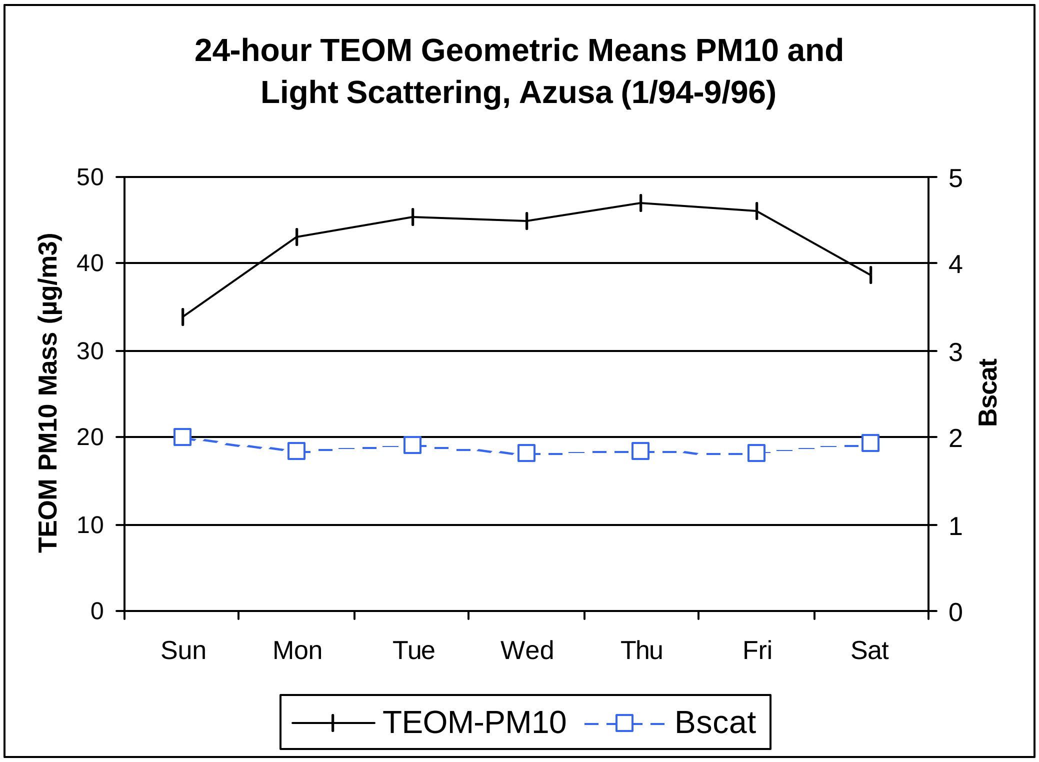
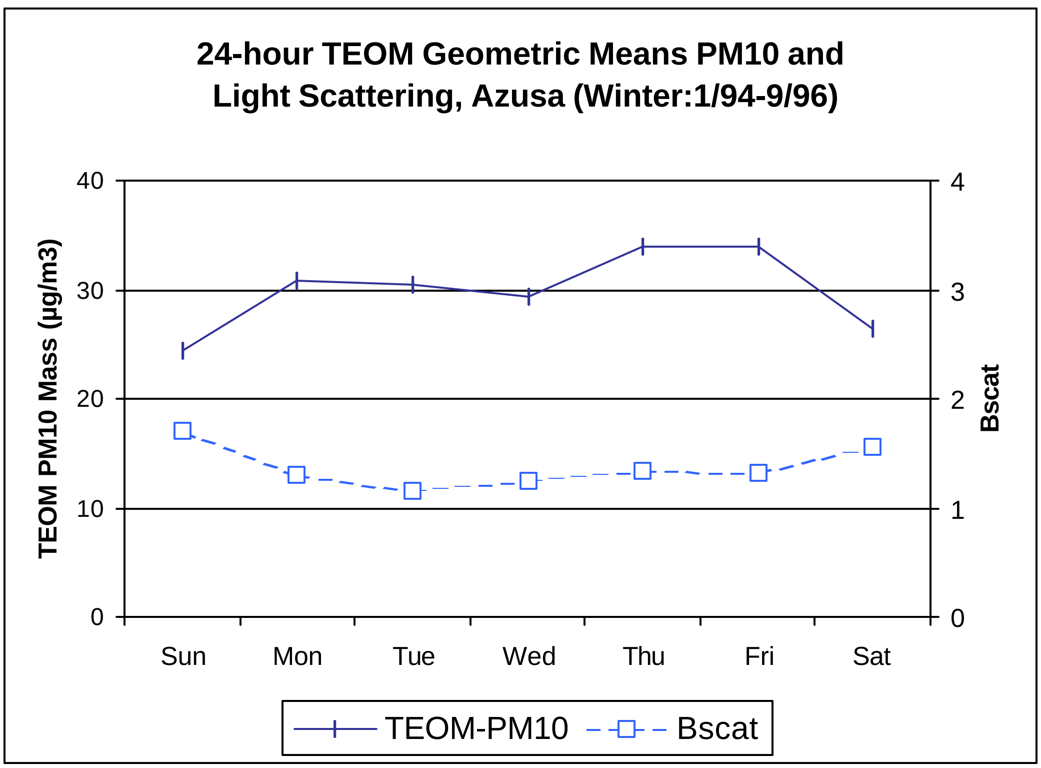
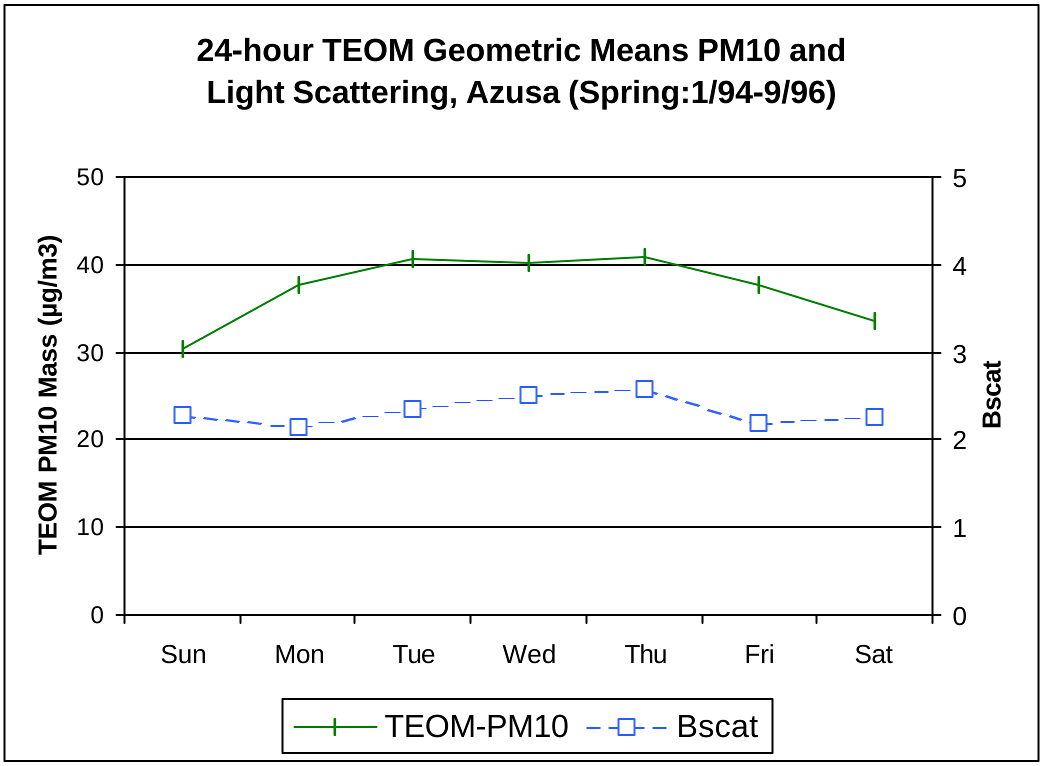
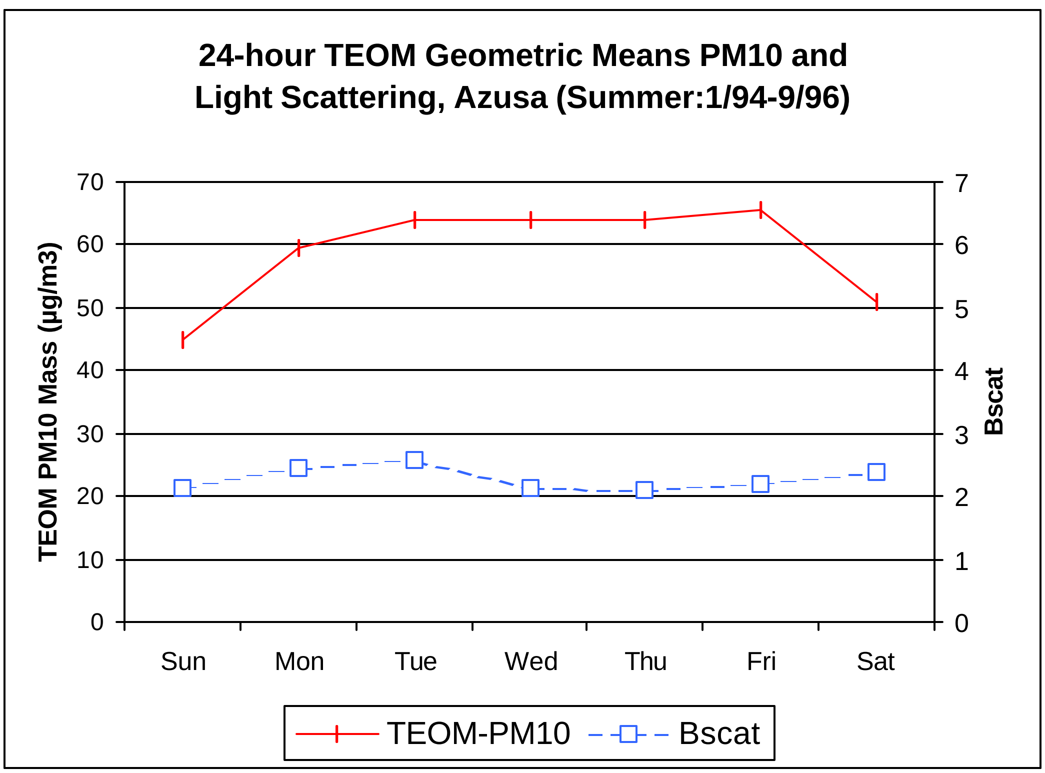


24-hour TEOM Geometric Means PM10 and
Light Scattering, Azusa (1/94-9/96)
TEOM PM10 Mass (µg/m3)
Bscat
0
10
20
30
40
50
0
1
2
3
4
5
Sun
Mon
Tue
Wed
Thu
Fri
Sat
TEOM-PM10
Bscat

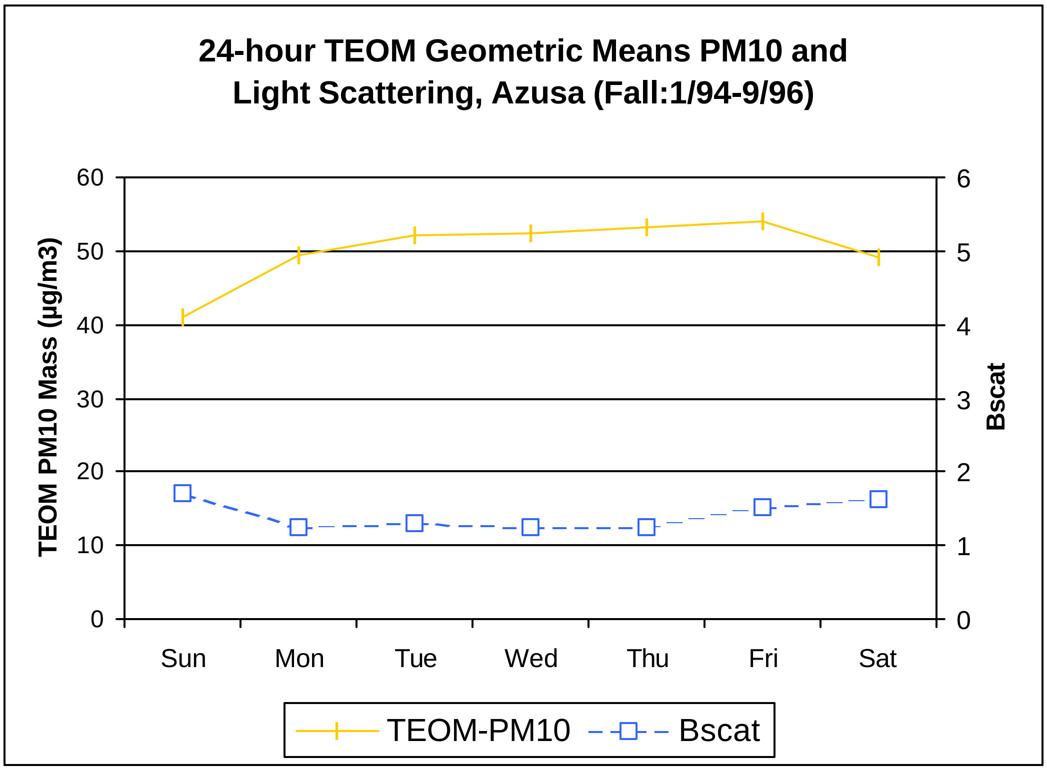


24-hour TEOM Geometric Means PM10 and
Light Scattering, Azusa (Winter:1/94-9/96)
TEOM PM10 Mass (µg/m3)
Bscat
0
10
20
30
40
0
1
2
3
4
Sun
Mon
Tue
Wed
Thu
Fri
Sat
TEOM-PM10
Bscat


24-hour TEOM Geometric Means PM10 and
Light Scattering, Azusa (Spring:1/94-9/96)
TEOM PM10 Mass (µg/m3)
Bscat
50
40
30
20
10
0
5
4
3
2
1
0
Sun
Mon
Tue
Wed
Thu
Fri
Sat
TEOM-PM10
Bscat

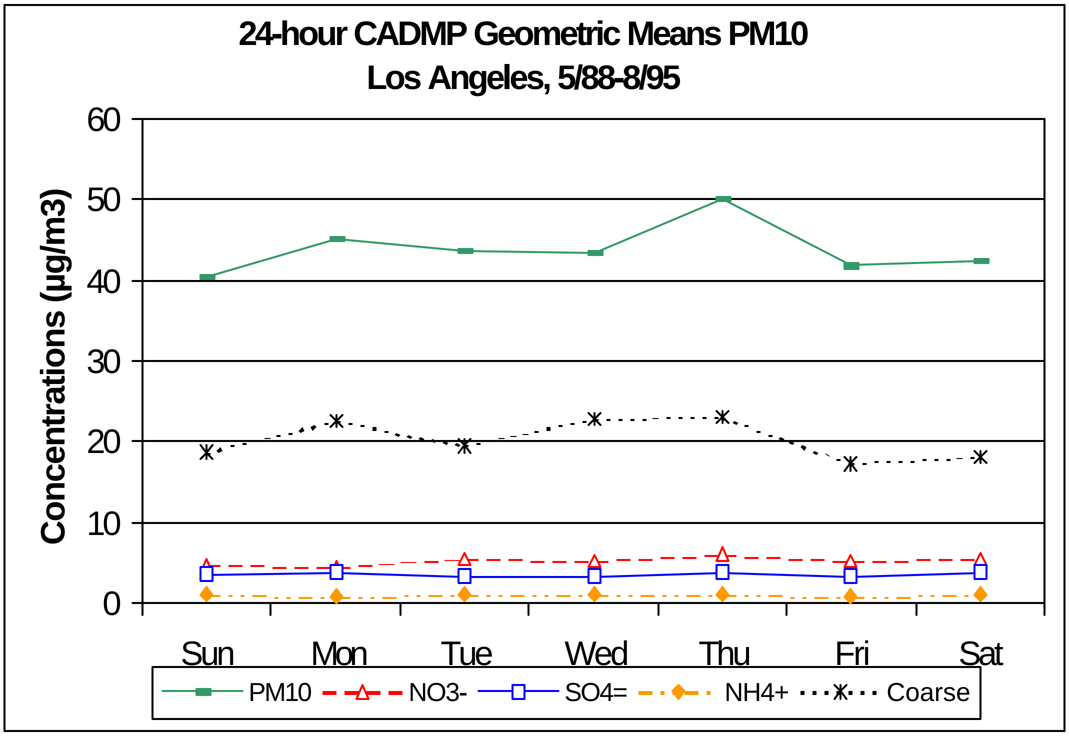

24-hour TEOM Geometric Means PM10 and
Light Scattering, Azusa (Summer:1/94-9/96)
TEOM PM10 Mass (µg/m3)
Bscat
70
60
50
40
30
20
10
0
7
6
5
4
3
2
1
0
Sun
Mon
Tue
Wed
Thu
Fri
Sat
TEOM-PM10
Bscat

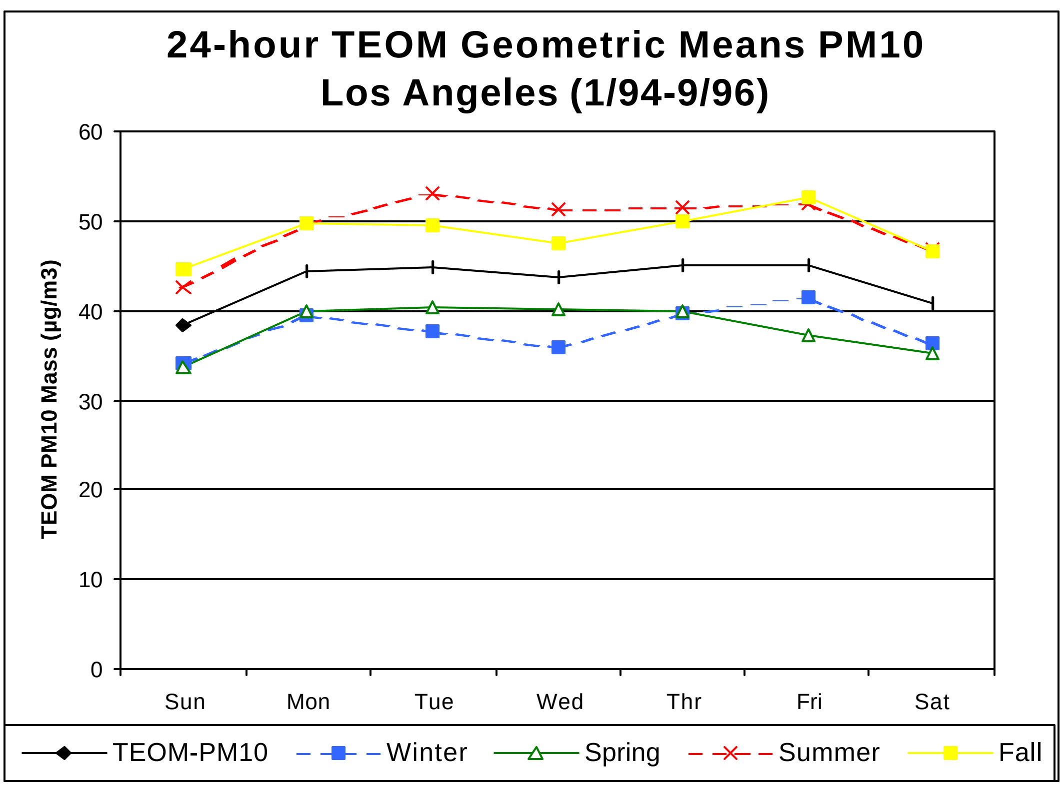
DRAFT

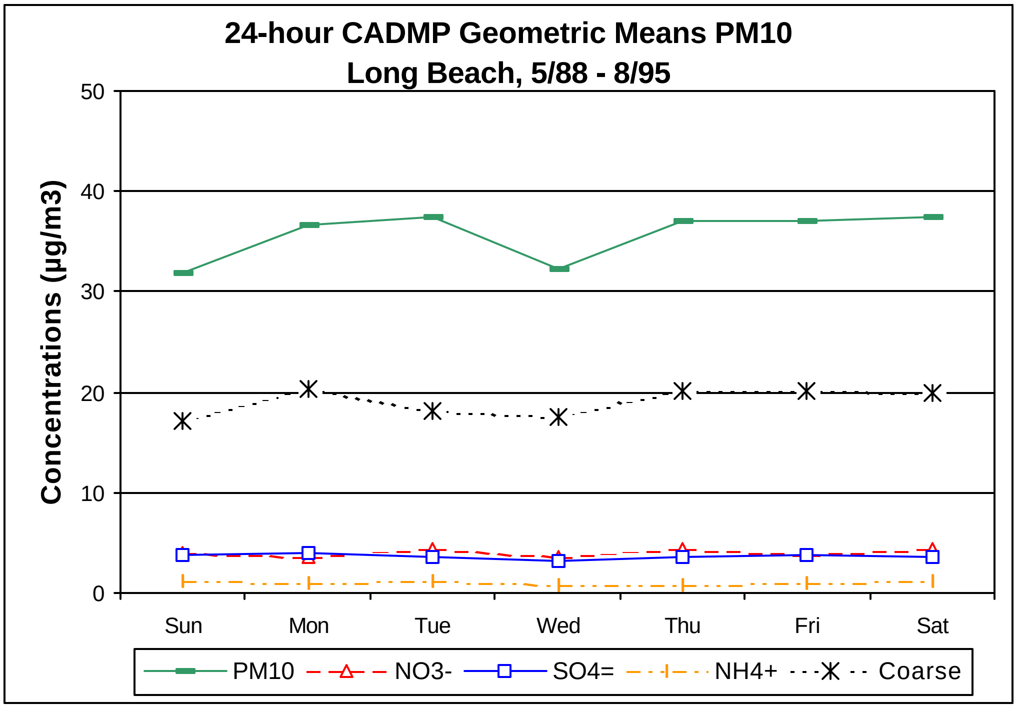


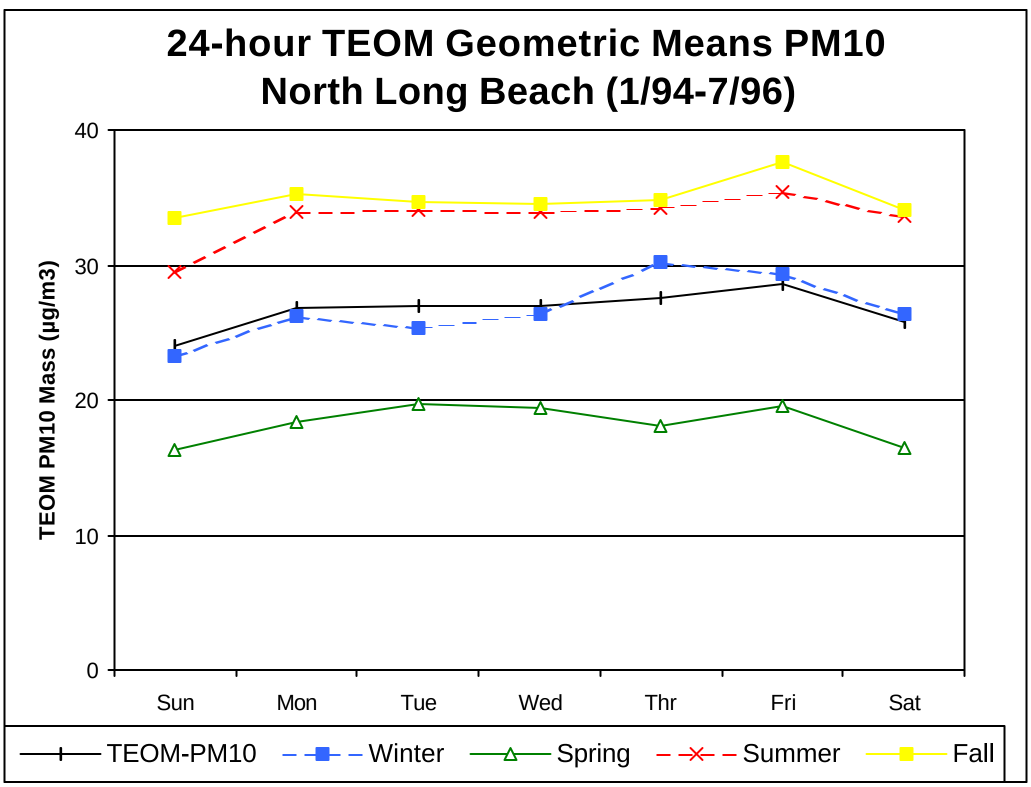
24-hour TEOM Geometric Means PM10 and
Light Scattering, Azusa (Fall:1/94-9/96)
TEOM PM10 Mass (µg/m3)
Bscat
60
50
40
30
20
10
0
6
5
4
3
2
1
0
Sun
Mon
Tue
Wed
Thu
Fri
Sat
TEOM-PM10
Bscat

DRAFT


24-hour CADMP Geometric Means PM10
Los Angeles, 5/88-8/95
Concentrations (µg/m3)
60
50
40
30
20
10
0
Sun
Mon
Tue
Wed
Thu
Fri
Sat
PM10
NO3-
SO4=
NH4+
Coarse


24-hour TEOM Geometric Means PM10
Los Angeles (1/94-9/96)
TEOM PM10 Mass (µg/m3)
60
50
40
30
20
10
0
Sun
Mon
Tue
Wed
Thr
Fri
Sat
TEOM-PM10
Winter
Spring
Summer
Fall


24-hour CADMP Geometric Means PM10
Long Beach, 5/88 - 8/95
Concentrations (µg/m3)
0
10
20
30
40
50
Sun
Mon
Tue
Wed
Thu
Fri
Sat
PM10
NO3-
SO4=
NH4+
Coarse


24-hour TEOM Geometric Means PM10
North Long Beach (1/94-7/96)
TEOM PM10 Mass (µg/m3)
0
10
20
30
40
Sun
Mon
Tue
Wed
Thr
Fri
Sat
TEOM-PM10
Winter
Spring
Summer
Fall

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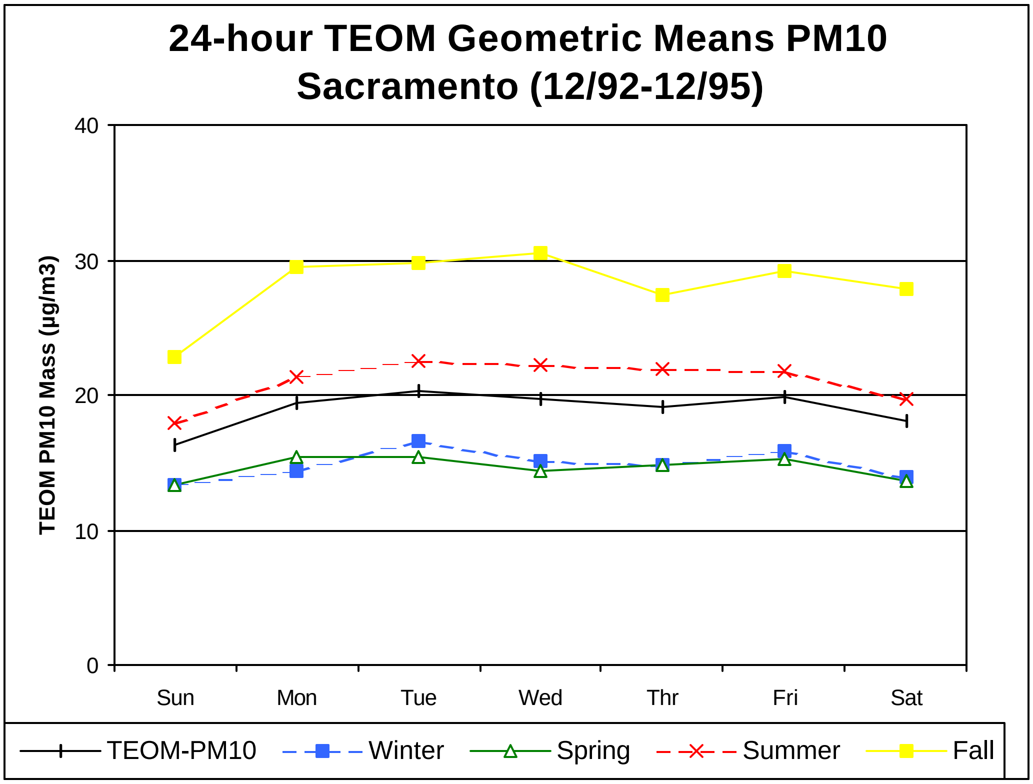
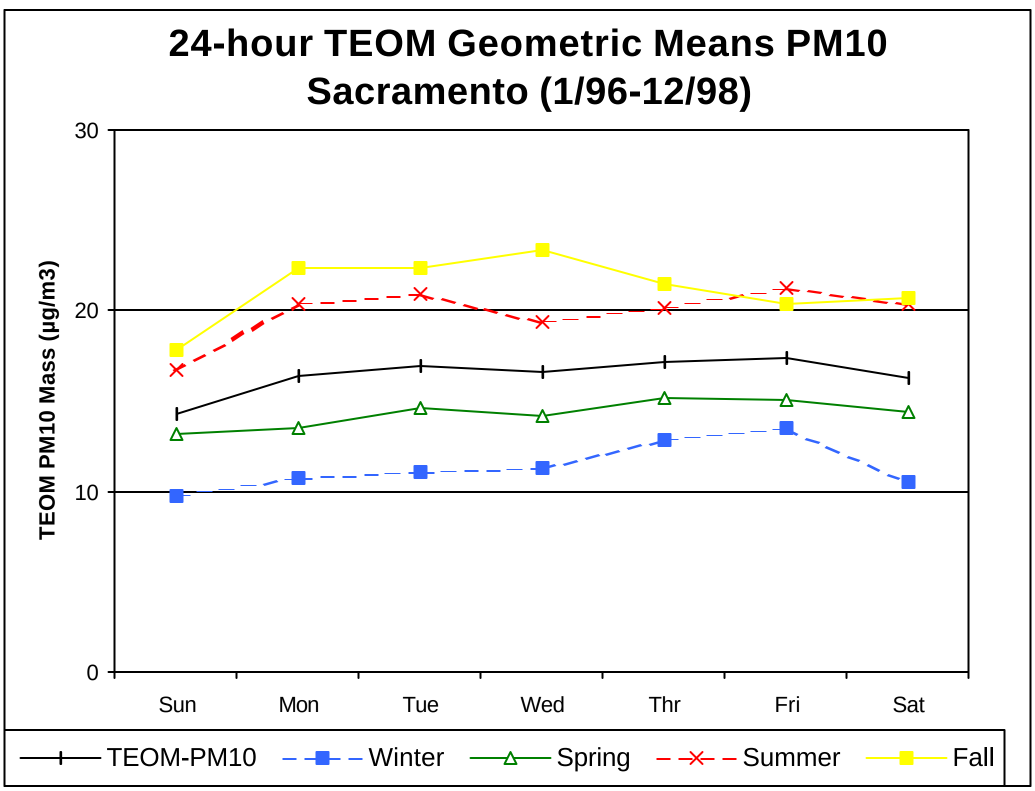

24-hour TEOM Geometric Means PM10
Sacramento (12/92-12/95)
TEOM PM10 Mass (µg/m3)
40
30
20
10
0
Sun
Mon
Tue
Wed
Thr
Fri
Sat
TEOM-PM10
Winter
Spring
Summer
Fall


24-hour TEOM Geometric Means PM10
Sacramento (1/96-12/98)
TEOM PM10 Mass (µg/m3)
30
20
10
0
Sun
Mon
Tue
Wed
Thr
Fri
Sat
TEOM-PM10
Winter
Spring
Summer
Fall

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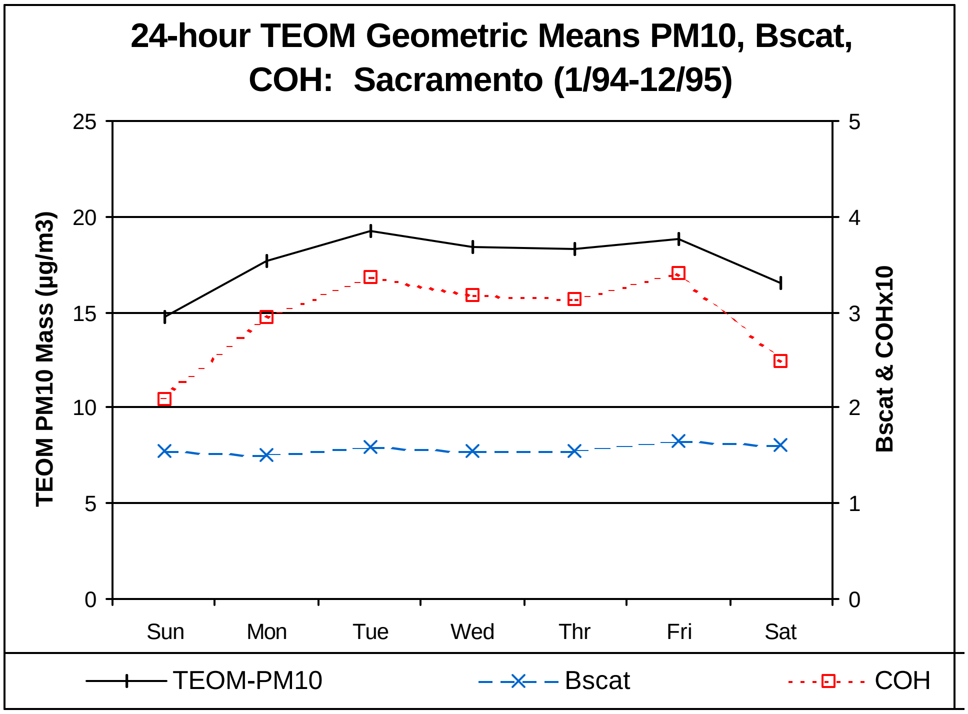
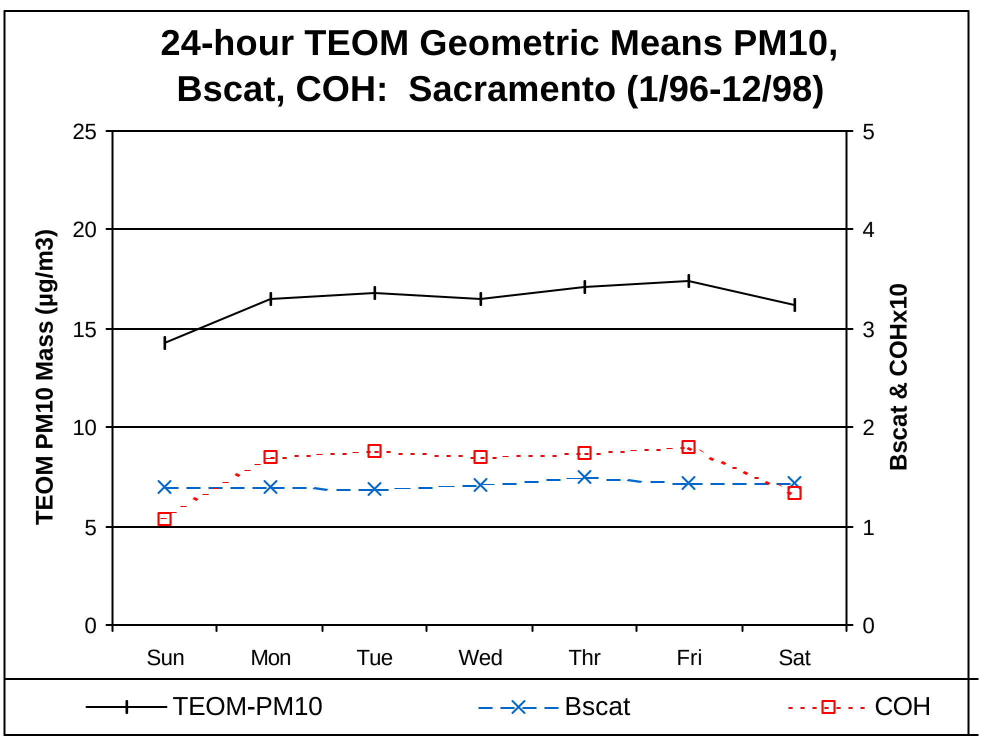

24-hour TEOM Geometric Means PM10, Bscat, COH: Sacramento (1/94-12/95)
TEOM PM10 Mass (µg/m3)
Bscat & COHx10
25
20
15
10
5
0
5
4
3
2
1
0
Sun
Mon
Tue
Wed
Thr
Fri
Sat
TEOM-PM10
Bscat
COH


24-hour TEOM Geometric Means PM10, Bscat, COH: Sacramento (1/96-12/98)
TEOM PM10 Mass (µg/m3)
Bscat & COHx10
25
20
15
10
5
0
5
4
3
2
1
0
Sun
Mon
Tue
Wed
Thr
Fri
Sat
TEOM-PM10
Bscat
COH

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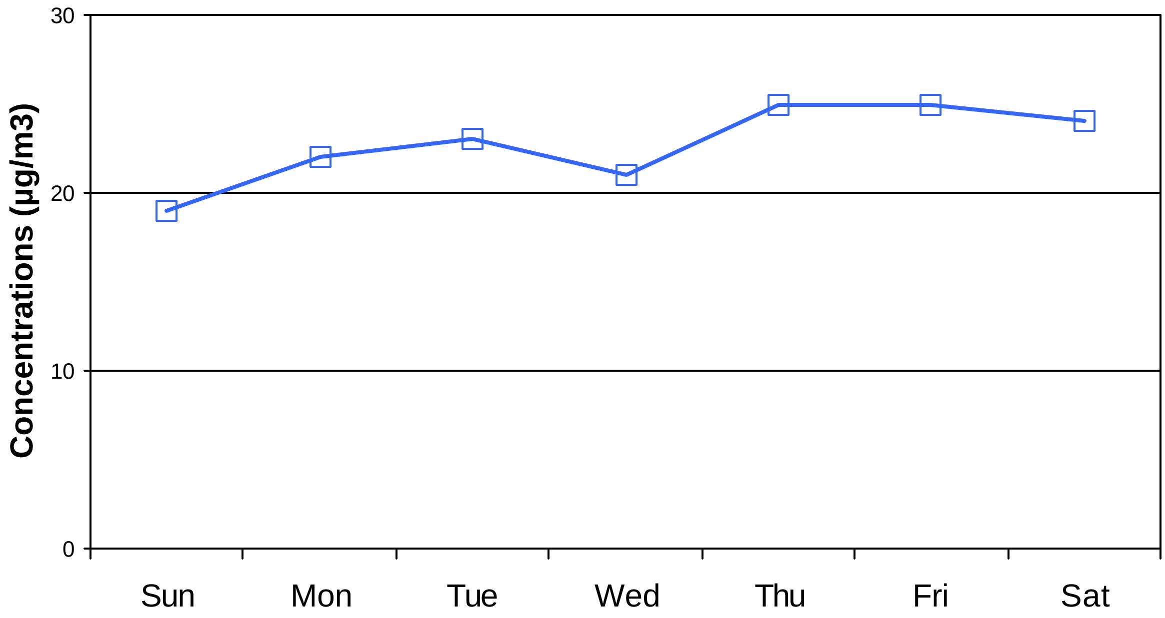
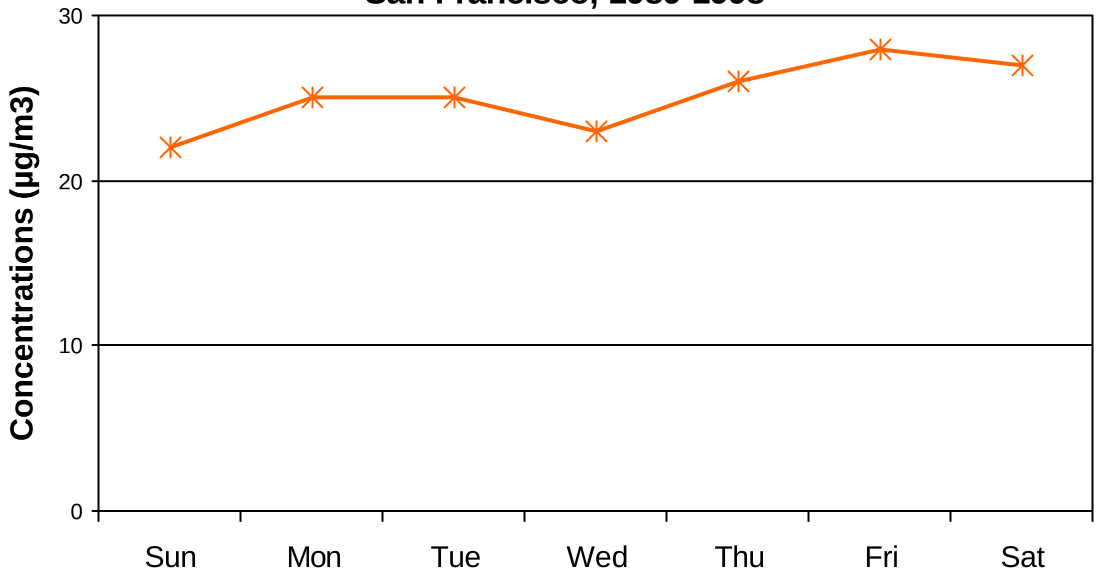
24-hour SSI Geometric Means PM10
Sacramento, 1989-1998



24-hour SSI Geometric Means PM10
San Francisco, 1989-1998



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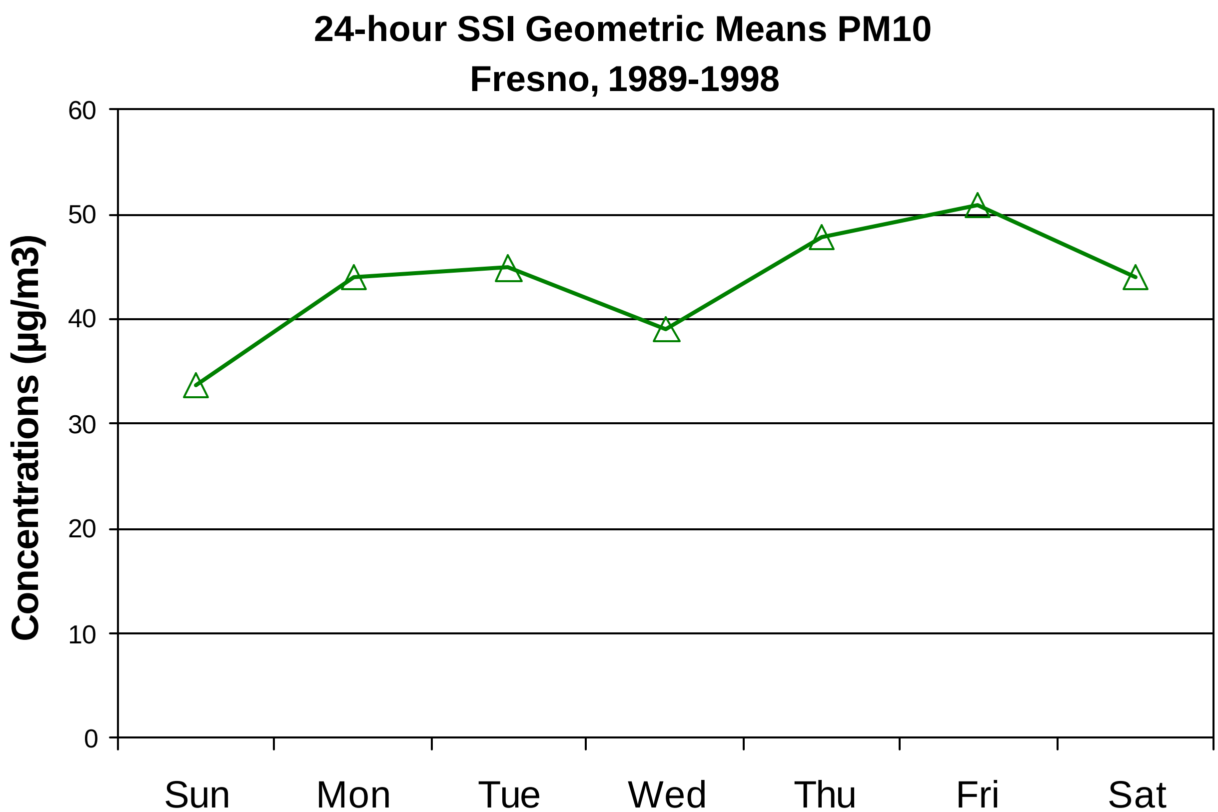

24-hour SSI Geometric Means PM10
Fresno, 1989-1998
Concentrations (µg/m3)
0
10
20
30
40
50
60
Sun
Mon
Tue
Wed
Thu
Fri
Sat

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